Table of Contents

Introduction ................. 4

People ......................... 7

Research ....................... 17

Teaching ....................... 46

Activities and Administration ................. 63
Dear research partners, colleagues, and students, dear friends:

I invite you to celebrate with us the first birthday of the Institute of Networked and Embedded Systems! Its foundation in January 2007 demonstrated the university’s commitment to a new emphasis in the area of information and communication technologies.

Since then many things have happened. Two new research groups have been established—the “Pervasive Computing Group” and the “Embedded Systems and Signal Processing Group.” My two new colleagues, Prof. Bernhard Rinner and Prof. Mario Huemer, did a great job in establishing their groups, acquiring first research funding and working out several courses. The institute grew from 6 to 23 permanent staff members and scholars. Many new lectures and courses for the new curriculum Information Technology have been offered, and also the number of enrolled students grew to almost one hundred.

This report gives an overview of our institute: the people, their research and teaching activities, and some social aspects illustrating our working atmosphere.

The research activities are grouped around the topics algorithms and protocols, architectures, networking theory, signal processing, and hardware-oriented issues, with a focus on wireless and mobile networks of pervasive devices and sensors. Our expertise includes cooperative wireless communications, networked cameras, synchronization and localization, self-organization in networks, and sensor fusion.

In the year 2007, two new externally-funded projects started, namely

- the “EVIs project” on autonomous traffic monitoring and
- the “SPARSE project” aiming at exploiting mobility in wireless networks.

Additional projects have been prepared and will start soon:

- the “RELAY project” on new techniques for cooperative communication in wireless networks,
- an FWF-funded project on communication architectures for robot systems,
- the “PowerDCDC project” on concepts and circuits for power management units funded by our local industrial partner Infineon Technologies Villach,
- the “VHD project” on very high data rates for near field communication funded by NXP Gratkorn, and
• a project on digital signal processing concepts for RFICs funded by DICE Linz and LCM Linz.

A major milestone of the year 2007 was the establishment of Lakeside Labs—a university-affiliated research platform with a technical focus on self-organizing networked systems. The technical and organizational orientation of the lab has been developed by all three professors of the institute. It will serve as an incubator for the ICT institutes of the university, providing about 3.5 Million EUR per year for an initial period of five years. In particular, it will enable larger projects with up to seven researchers working on visionary and multidisciplinary projects. With involvement of several institute members, we defined a scientific and organizational framework and are currently in the stage of starting first research projects.

A lot of our time has been invested in teaching, covering bachelor, master, and PhD courses for the study programs Information Technology and Informatics. New undergraduate lectures include the second semester course on Electronic Circuits and the two third semester courses on Systems Theory and Communication Engineering and Design of Digital Circuits. At the graduate level, several new lectures in the areas of pervasive computing and signal processing as well as a new lab course on embedded microcontrollers have been established.

Furthermore, we continued our series of guest lectures. One of the teaching highlights has been the lecture Communication Theory in Mobile Systems and Genetics by Prof. Joachim Hagenauer which was very well received by our students.

Preparations for a new, very comprehensive ICT lab course, in which students will gain valuable hands-on experience, are underway.

Several staff members were (and still are) engaged in committees of the university and in the research community. As two highlights, I would like to mention the First ACM/IEEE International Conference on Distributed Smart Cameras organized by the Pervasive Computing Group and the election of Prof. Rinner as vice dean of our department.

Last but not least, the institute’s technical infrastructure has been extended significantly, including a new server pool for high-performance simulations, large network storages, and lab equipment.

Enjoy this report, and thanks to all who make this institute what it is!

Christian Bettstetter
Professor and Institute Head
Our Mission

The **Embedded Systems and Signal Processing Group** focuses on system-, algorithmic-, architectural- and hardware-oriented aspects of embedded systems. Application areas are short range and cellular wireless systems, wireless positioning systems as well as automotive applications. Our vision is to work on long-term research projects as well as on short-term topics, the latter in close cooperation with industry partners. In teaching we are involved in the bachelor and master programs Information Technology, where we are committed to giving high quality lectures and lab courses. In addition we provide optimum conditions for diploma and master theses, student projects, and internships. Established in March 2007, the group is lead by Prof. Mario Huemer.

The **Mobile Systems Group** works on the design, modeling, and analysis of future mobile and wireless systems. We are engaged in research on algorithms and protocols, networking theory, modeling and simulation aspects, and system architectures. Four networking paradigms are currently in the core of our activities: self-organization, ad hoc relaying, cooperation, and mobility. Our target application areas are telecommunications, networked embedded systems, pervasive computing, and disaster management. Our teaching covers graduate courses on mobile networking and wireless communications and undergraduate courses on electricity and magnetism. Established in October 2005 the group is lead by Prof. Christian Bettstetter.

The research of the **Pervasive Computing Group** is focused on theoretical and practical aspects of innovative pervasive and ubiquitous computing. Research topics include smart cameras, sensor networks, sensor fusion and embedded signal processing architectures. Our research is conducted in close cooperation with national and international partners both in academia as well as in industry. Our teaching activities cover fundamentals, technologies and applications of pervasive computing for students of Information Technology and Informatics. Dedicated lab courses help students to acquire practical experiences, and seminars address recent topics of pervasive computing research. At the graduate level, we currently offer courses on fundamentals and advanced topics on pervasive computing, digital signal processors and radio frequency identification (RFID). At the undergraduate level, we offer a lecture on digital system design and a lab course on fundamentals of ICT. Founded in March 2007 the group is lead by Prof. Bernhard Rinner.
People
Embedded Systems and Signal Processing

Professor

Mario Huemer

Mario Huemer received the Dipl.-Ing. degree in Mechatronics and the Dr.techn. (Ph.D.) degree from the Johannes Kepler University of Linz, Austria, in 1996 and 1999, respectively. Before joining Klagenfurt University he was with the University of Linz (1997-2000), Infineon Technologies Austria (2000-2002), the University of Applied Sciences of Upper Austria (2002-2004), and the University of Erlangen-Nuremberg, Germany (2004-2007), where he held the position of an associate professor. In March 2007 he was appointed as a full professor for embedded systems at Klagenfurt University. He authored and co-authored 20 articles in journals, magazines, and books, and about 70 papers in conference proceedings. He is member of the IEEE, VDE, EURASIP, and ÖVE.

Office Management

Ursula Rotter

Ursula Rotter was born in Klagenfurt in 1974. After A-level at the secondary educational establishment for financial occupations in Klagenfurt she passed a young entrepreneurs-training at the WIFI. In 1995 she started her basic training for civil service at Klagenfurt University. During her work at the Admission Department and later at the Faculty for Interdisciplinary Research she started to study Education specializing in Adult and Vocational Education which she finished in May 1995. From 1999 – 2007 she worked as secretary at the press department. Since April 2007 she supports the Embedded Systems and Signal Processing Group.
Christian Hofbauer
Research Staff member since 01.09.2007

Christian Hofbauer was born in St. Peter am Wimberg, Austria, in 1982. From 2002 to 2006, he studied Hardware/Software Systems Engineering at the University of Applied Sciences of Upper Austria. He received his Dipl.-Ing. (FH) degree in 2006. He did his internship and made his diploma thesis at the research institute IMEC in Belgium. In September he joined the Embedded Systems and Signal Processing Group. Currently, he focuses his research activities on physical layer aspects of cooperative relaying.

Christian Lederer
Research and Teaching Staff member since 01.12.2007

Christian Lederer was born in Villach in 1982. His technical education started at the HTL for Electronics, Telecommunication and Computer Techniques in Klagenfurt. After school he was working at the Carinthian Tech Research (CTR) till he started his studies of Telematics at the University of Technology in Graz. During the studies he was involved in several projects for the automotive industry and wrote his master thesis in the field of “Chipcards” at Infineon. In December 2007 he joined the Embedded Systems and Signal Processing Group.

Jakob Mayring
System Administrator since 01.07.2007

Jakob Mayring was born in Munich in 1983. He moved to Klagenfurt in 2002. During his school days he helped to plan and deploy photovoltaic systems. In Klagenfurt he finished the school and enrolled in the bachelor program of computer science at the University of Klagenfurt in 2003. In the winter semester 2006/2007 he worked at the Information Technology Services of the University (Zentraler Informatik Dienst). In July 2007 he brought this knowledge to the Embedded Systems and Signal Processing Group where he is working as a System Administrator.
Alexander Onic
Research and Teaching Staff member since 15.04.2007

Alexander Onic was born in 1981. He started his studies of electrical engineering at the University of Erlangen-Nuremberg in 2001. After choosing information technology as his major subject he emphasized on signal processing and information theory in his education. He concluded his studies and received the Dipl.-Ing. degree in April 2007. In the same month he joined the Embedded Systems and Signal Processing Group at Klagenfurt University. His current research focuses on the theory and on applications of compressive sampling.

Robert Priewasser
Research Staff member since 15.09.2007

Robert Priewasser was born in Salzburg, Austria, in 1982. He received the Dipl.-Ing. (FH) degree at the University of Applied Sciences of Upper Austria, study direction Hardware Software Systems Engineering with distinction. During his studies he spent 9 months at the research institute IMEC in Belgium, working on low power design for a wireless software defined radio platform. He also wrote his diploma thesis at IMEC in the field of forward error correction codes. In autumn 2007 he started his PhD work in Klagenfurt. The research focus is on efficient power supplies for embedded platforms in general, and on PWM-based DC-DC converters specifically.

Thomas Schlechter
Research and Teaching Staff member since 01.04.2007

Thomas Schlechter was born in Treuchtlingen, Germany, in 1979. He received the Dipl.-Ing. degree in EEI (Electrical Engineering, Electronics and Information Technology) from the University of Erlangen-Nuremberg, Germany, in 2007. In April 2007 he moved to Klagenfurt, where he is working as a research and teaching staff member at the Embedded Systems and Signal Processing Group. In Klagenfurt he is doing research in the field of RFID/NFC in cooperation with the company NXP, Gratkorn, Austria.
Christian Bettstetter

Christian Bettstetter studied electrical engineering and information technology at the Technische Universität München, Germany, where he received the Dr.-Ing. (summa cum laude) and Dipl.-Ing. degree in 2004 and 1998, respectively. From 2003 to 2005, Christian was a senior researcher at DoCoMo Euro-Labs. From 1998 to 2003, he was a research and teaching staff member at the Institute of Communication Networks at TU München. He co-authored the Wiley book “GSM - Switching, services and protocols,” and published 20 articles in journals, magazines, and books, and more than 40 papers in conference proceedings. One of this papers received the 2004 outstanding paper award from the German ITG. In 2005, he was appointed as a full professor for mobile systems at the Alpen-Adria-Universität Klagenfurt.

Andrea Krammer

Andrea Krammer did her language studies at the Karl-Franzens-Universität Graz, the Università per Stranieri and the Università degli Studi (Italy), and she spent a year in Milan teaching German as a foreign language. She obtained a Master of Arts in German and Italian (Secondary School Teacher Accreditation) (with distinction) from the University of Klagenfurt in 2001. Before she joined the mobile systems group, she worked as a teacher and trainer in Austria and Italy and as an office manager at the European Academy of Sciences and Arts in Vienna.
Helmut Adam

Research and Teaching Staff member since 01.04.2006

Helmut Adam studied telematics at TU Graz, where he received the DI degree in 2005. In the course of his master thesis, which was in the field of wireless sensor networks, he worked at the sense and control department of Infineon Technologies Austria. After his graduation he rejoined Infineon as a verification engineer responsible for sensor networks and the automation of chip verification. At the mobile systems group, his research area is in the field of cooperative spatial diversity in wireless ad hoc networks. He is also tutoring an introductory course about electrical engineering and physics for information technology.

Günther Brandner

System Administrator since 01.03.2007

Günther Brandner was born in 1982. He attended the Business Academy in Villach and worked for a Credit Institute between September 2001 and January 2002. After military service he began studying computer science at the University of Klagenfurt, where he received the Master of Science with distinction in 2007. Since 2005 he is also studying technical mathematics. In March 2007 he joined the Mobile Systems Group as a system administrator and junior researcher.

Sérgio Crisóstomo

Research Scholar since 01.10.2006

Sérgio Crisóstomo studied electrical and computer engineering at the University of Porto, where he received the MSc and Dipl.-Ing. degree in 2003 and 1997, respectively. From 1997 to 2002 he worked as a researcher at INESC Porto. From 2002 to 2006 he was a researcher at the Laboratory of Artificial Intelligence and Computer Science, University of Porto, and was teaching at the same university. In 2006, he was granted a PhD fellowship from the Portuguese Science & Technology Foundation, and is now doing its PhD research at the Mobile Systems Group. His topic is network coding in dynamic networks with focus on algorithmic and protocol aspects.
Dominik Egarter

*Student System Administrator since 03.12.2007*

Dominik Egarter was born in 1986 in Spittal an der Drau. He attended the Higher Technical School in Klagenfurt for Electrical Engineering and graduated in 2007. Since autumn 2007 he is a student at the University of Klagenfurt. He studies information technology. In December 2007 he joined the Mobile System Group as a part-time technician. His tasks are to maintain the homepage of the institute and to organize orders. Furthermore he is responsible for technical support of IT infrastructure.

Wilfried Elmenreich

*Senior Research Staff member since 05.11.2007*

Wilfried Elmenreich graduated at the Vienna University of Technology where he received a Master’s degree in computer science in 1998 and a Ph.D. degree in technical sciences in 2002. His doctoral thesis addressed the sensor fusion problem in time-triggered systems. Wilfried contributed significantly to the development of the TTP/A fieldbus protocol and the standardization of the OMG Smart Transducer Interface. In the last five years, he has published over 40 papers in the field of embedded real-time systems. Wilfried is affiliated with the Mobile Systems Group as a senior researcher for Lakeside Labs, a research center investigating self-organizing networked systems.

Michael Gyarmati

*Research and Teaching Staff member since 01.06.2006*

Michael Gyarmati studied telematics at TU Graz between 1999 and 2005, where he received the Dipl.-Ing. degree with distinction. In parallel to telematics he has been studying for a teaching degree in computer science and mathematics at the University of Klagenfurt (expected graduation: 2008). In 2002 he spent a year at the University of Leeds, UK. He also worked as a software engineer at CISC Semiconductor. His research focuses on aspects on how to exploit mobility of mobile entities in wireless communications and how those findings can be adopted to benefit future wireless applications.
Udo Schilcher
Research and Teaching Staff member since 01.12.2005

Udo Schilcher studied applied computing and technical mathematics at the University of Klagenfurt, where he received two Dipl.-Ing. degrees (with distinction) in 2005 and 2006, respectively. He contributed in the standardization of the Mobile IKE protocol and the area of number theory and cryptography. He is now working for the mobile systems group, where his research topic is cooperative networking and network coding. He teaches exercises in mobile and wireless systems and a lab about network simulation.

Alexander Tyrrell
Research Scholar since 01.11.2005

Alexander Tyrrell studied at the Ecole Supérieure d’Ingénieurs en Électronique et Electrotechnique (ESIEE) in Paris, where he received a master degree in electrical engineering with a major in signal processing and telecommunications in 2005. He also did a master of research in digital telecommunications systems at the École Nationale Supérieure des Télécommunications (ENST) in Paris. In 2003 he spent a semester at Chalmers University. From 2003 to 2004, he worked as a DSP support engineer at Texas Instruments in Freising, Germany. In 2005, he started as a PhD scholar at DoCoMo Euro-Labs in Munich, Germany, under the supervision of Christian Bettstetter.
Bernhard Rinner

Bernhard Rinner received both his PhD and MSc in Telematics from Graz University of Technology in 1996 and 1993, respectively. Before joining Klagenfurt University he was with Graz University of Technology and held research positions at the Department of Computer Sciences at the University of Texas at Austin in 1995 and 1998/99. His research interests include parallel and distributed processing, embedded systems as well as mobile and pervasive computing. Bernhard Rinner is currently working on pervasive computer systems, multi-DSP architectures, embedded multimedia systems, and distributed smart cameras. He has authored and co-authored more than 80 papers for journals, conferences and workshops, lead several research projects and served as reviewer, program committee member, program chair and editor-in-chief. He is member of the IEEE and IFIP.

Heidelies Aschbacher

Heidelies Aschbacher was born in 1977 in Klagenfurt, Austria. She attended the Business Academy in Feldkirchen and graduated 1996. Heidelies started her professional education in tourism. She was employed as front- and backoffice manager and as manager’s assistant in hotels of premium categories and was responsible for sales and marketing. In Winter 2001 she spent 6 months working in South America. In 2005 she decided for an occupational change and started to work as sales manager for both national and international businesses. Since April 2007 she supports the Pervasive Computing Group as secretary.
Wolfgang Schriebl
Research and Teaching Staff member since 01.06.2007

Wolfgang Schriebl was born in 1979 in Voitsberg, Austria. He studied Teleinformatics at Graz University of Technology, where he did his master thesis in the field of embedded video surveillance systems at the Institute for Technical Informatics (ITI). In June 2007, after working for one year as an embedded software engineer at Efkon AG, he joined the Pervasive Computing Group at Klagenfurt University as a research and teaching staff member. His current research interests are in the field of pervasive smart cameras, with a focus on smart camera architectures for distributed embedded vision.

Andreas Starzacher
Research Staff member since 14.05.2007

Andreas Starzacher was born in 1982 in Klagenfurt, Austria. He studied Informatics at the University of Klagenfurt specializing in interactive systems. In May 2007 he received his Dipl.-Ing. degree, doing his master thesis in the field of intelligent vehicle technologies at the Institute of Smart System Technologies. In the same month he joined the Pervasive Computing Group as a scientific project member. He is currently working on the “EViS” project focusing on embedded systems technologies and sensor fusion.

Gerald Topar
System Administrator since 01.06.2007

Gerald Topar was born in 1981 in Klagenfurt, Austria. He attended the HTL in Klagenfurt for Technical Informatics and graduated in 2000. In spring 2001 he joined the company GLOCK in Ferlach, Austria as a member of the data processing department. In summer 2006 he received his Ing. degree. From July 2006 till May 2007 he was employed at the company Wernig in Unterbergen near Ferlach, Austria. In June 2007 he joined the Pervasive Computing Group at the University. He is responsible for the institute’s server-infrastructure, the information and communication technology laboratory, the IT-support for the Pervasive Computing group.
Thomas Winkler was born in 1980 in Graz, Austria. He studied Telematics at Graz University of Technology. In 2005 he earned his Dipl.-Ing. degree, doing his thesis in the field of embedded video surveillance systems at the Institute for Technical Informatics (ITI). In fall 2005 he joined the Institute for Applied Information Processing and Communications (IAIK) as a member of the EU research project “Open Trusted Computing” working on embedded security solutions. In May 2007 he joined the Pervasive Computing Group. His research is focused on pervasive smart camera systems covering system architectures as well as operating system and middleware aspects.

**Guest Researchers**

- Dr. Joao Barros, Universidade de Porto, 30.-31.01.2007.
- Univ.-Prof. Dr. Joachim Hagenauer, TU München, 01.-09.06.2007.
- Dr. Christian Hartmann, TU München, 15.-20.05.2007
- Dr. Ulrich Neffe, NXP Semiconductors Austria GmbH Styria, Oct. 2007.
- Dipl.-Ing. Robert Vilzmann, TU München, 18.-24.06.2007

**Student Assistants**

- Michal Filip Gurtowski, master student in Informatics, 01.10.2007-31.01.2008
- Francesco Mario Pivk, master student Informatics, 1.10.2007-31.01.2008
- Michael Strutz, bachelor student in Information Technology, 01.10.2007-31.01.2008
- Hima Deepthi Vankayalapati, master student Information Technology, 01.10.2007-31.01.2008
- Manuel Warum, bachelor student in Informatics, 01.08.2007-21.09.2007
The NES institute works on the design, modeling, and analysis of future networked and embedded systems. Potential application areas include telecommunications, mobile computing, and disaster management. Our project portfolio includes both long-term and short-term research. Several projects are in close cooperation with industrial and academic partners. The following pages give an overview of our research activities and collaborators and explain in more detail some selected research topics.

**Academic Partners**

- Austrian Center of Competence in Mechatronics, Linz, Austria. Joint research activities.
- IMEC, Belgium. Joint master theses and internships.
- Georgia Tech, USA. Joint research activities.
- KAI GmbH, Villach, Austria. Two external PhD students.
- Soongsil University, Seoul, Korea. Research contract.
- TU Graz, Austria. Joint research projects and four PhD students.
- University of Erlangen-Nuremberg, Germany. Three external PhD students.
- University of Linz, Austria. Guest professorship
- University of Porto, Portugal. Joint research activities and joint PhD student.

**Industrial Partners**

- Infineon Technologies AG, Munich, Germany. Four external PhD students.
- DICE Linz GmbH. Joint research activities and external PhD student.
- Siemens AG Munich, Germany. External PhD students and EU project RESOLUTION.
- EFKON AG Graz, Austria. Research project, 05/2007-04/2010
- DoCoMo Communications Laboratories Europe GmbH, Munich, Germany. Research scholarship, joint PhD student.

**Main Funding**

- The institute receives its main funding from the Carinthian Economic Promotion Fund (KWF).
- Middleware for network eccentric and mobile applications (MiNEMA), funded by the European Science Foundation (ESF), Steering board member from 01/06 until 12/08
- Portuguese Science and Technology Fund (FCT), Portugal, Research scholarship, since 10/2006

**Other Sponsors**

- Texas Instruments Germany GmbH. Lab equipment.
- IBM Austria. Conference Sponsorship.
- Altera Corporation, California, USA. Lab equipment.
- Sun Microsystems GmbH, Vienna. Lab equipment.
Overview
The Embedded Systems and Signal Processing Group focuses on the system-, algorithmic-, architectural- and hardware-oriented aspects of embedded systems. Application areas are short range and cellular wireless systems, wireless positioning systems as well as automotive applications.
Our vision is to work on long term research projects as well as on short term topics, the latter in close cooperation with industry partners.

Research projects
We succeeded in starting projects and co-operations with excellent industry and scientific partners. The following projects are fully or partly funded by our research partners:

- Power DCDC: Power management for DC-DC converters funded by Infineon Technologies Austria
- RELAY: Cooperative Relaying in Wireless Networks funded by Lakeside Labs GmbH
- VHD: Very High Data Rates for Contactless Smartcard Devices funded by NXP Semiconductors Austria GmbH
- Digital Signal Processing Concepts for RFICs funded by LCM Linz and DICE Linz GmbH

Furthermore we work on a strategic, long term fundamental research project in the field of Compressive Sampling/Compressive Sensing.

Project proposal submissions
The Embedded Systems and Signal Processing Group is part of a large consortium, which submitted a large-scale integrating project (IP) proposal to the European Commission within the Objective ICT-2007.6.3 (ICT for environmental Management and Energy Efficiency) in 2007.

Together with Infineon Technologies Austria a project proposal for Lakeside Labs in the area of Power management for DC-DC converters is in preparation.
In recent years, a lot of attention has been drawn on diversity techniques enabled by multiple antenna systems. Due to the different locations of the antennas, spatial diversity is provided. In combination with temporal diversity, effective techniques have been developed in order to mitigate the negative effects of multipath propagation, noise or attenuation, which therefore leads to an improved transmission. While these attributes are desirable, several problems arise when implementing these MIMO (Multiple Input Multiple Output) concepts, especially when applying them to mobile terminals. As such, issues like positioning several antennas on a small handheld device become quickly an essential hurdle for practical systems. Hence, ideas are required to still exploit the advantages of the MIMO technique while handling the problems of this approach in an effective manner.

Recently, a new form of realizing spatial diversity, namely cooperative diversity, has gained significant interest in the research community. The main idea is that several single antenna devices cooperate in some fashion in order to transfer the data from the transmitter to the receiver. In such a network, several devices act as relays for an active source/destination pair, leading to spatial diversity in a distributed fashion. Thus, low complexity transceivers can be used while utilizing the advantages of conventional multiple antenna systems. Furthermore, due to the low complexity, this concept can not only be used for conventional infrastructure networks, but it is also likely to be applicable to wireless sensor networks as well.

This project will thus perform research on cooperative diversity relaying in the context of self-organizing wireless networks, focusing on physical layer aspects. System related aspects in terms of how the relays will support the transmissions, will be investigated and assessed based on their performance as well as on their applicability for practical systems. As such, virtual antenna arrays, distributed beamforming with limited feedback and precoding are techniques to be focused on. Moreover, appropriate modulation schemes, such as hierarchical modulation, will be taken into account as well. This approach is based on the idea that the modulation scheme can be interpreted as a scheme with high order by receivers close to the transmitter, and as a scheme with lower order by receivers far away from the transmitter.

Furthermore, techniques for channel estimation and equalization will also be investigated, as they are known to have a significant impact on the performance and complexity of a system. As an overall goal, the research activities aim at optimizing the bit error behaviour and/or the system’s energy efficiency. However, in order to keep the algorithms applicable for practical scenarios, certain parameters like the amount and kind of required channel information - from limited to full channel knowledge - and computational complexity on one hand, and achievable network capacity and/or link reliability on the other hand, have to be well traded against each other.

The research methodology will mainly include simulation-based studies and implementation on off-the-shelf hardware. From April 2008 on the project will be funded by Lakeside Labs.
Current transceivers for mobile communication devices supporting UMTS and/or HSPA are operating in full-duplex mode. That means that the transmitter and the receiver are operating at the same time, but at different frequency bands (Frequency Division Duplex). Transmitter signals, which exhibit much more power compared to the receive signals, may leak into the receiver path because of non-linearities and/or out of band emissions. These leakage signals will be processed by the receiver path and so they disturb the signal which should actually be received. Unfortunately the amplitudes of the leakage signals can be much higher than the wanted signal, with the effect, that the wanted signal may be heavily distorted.

Normally excessive filtering (typically using Surface Acoustic Wave (SAW) filters) is done in the RF band to eliminate the spurious signals. But such SAW filters are discrete devices that cannot be integrated into an IC, which furthermore increases the costs of the whole transceiver. For higher integration, the SAW filters have to be eliminated from the transmitter and receiver chain. The idea is now to replace the analogue filters by digital signal processing in the digital front end (DFE). A further advantage of processing in the digital domain is that digital integrated circuits scale well with the change of the semiconductor technologies, which is not possible in the same degree for analogue integrated circuits. This research project is done in cooperation with DICE GmbH & Co KG and with LCM (Linz Center of Mechatronics).
Compressive Sampling / Compressed Sensing
Alexander Onic and Mario Huemer

In order to acquire analog physical signals and all contained information the analog-to-digital-conversion needs to be designed adequately. Presently the Nyquist frequency is the mandatory minimum sampling frequency for almost every type of signal. In recent publications a technique called Compressive Sampling or Compressed Sensing came up that allows sampling of some classes of signals far below the Nyquist frequency. The new methods allow exact signal reconstruction from sub-Nyquist sampled data with high probability [2]. Even higher is the probability of reconstructing the signal within defined error bounds. These reconstruction methods lie in the field of optimization theory and operations research.

Most signals meet the necessary preconditions for compressive sampling and so many applications can gain from the technique:

- Bajwa et al. [1] describe a wireless sensor network whose signal is acquired by a fusion center using Compressive Sampling for alleviating noise and measurement deviations.
- In decentralized sensor networks power consumption is the crucial resource for system design. A lower sampling frequency could lower power consumption significantly.
- Analog signals can be acquired in an already compressed fashion without the use of entropy coding simply by sampling below the Nyquist frequency.
- Candes mentions medical imaging applications like the MRT (magnetic resonance tomography) [2], in which incomplete frequency information needs to be dealt with on physical conditions.
- Sensing a wide spectrum used to require a very high sampling frequency. If the signal expected to be found only has a narrow bandwidth, Compressive Sampling can help making the process much more efficient.
- Technology Review also considers Compressed Sensing for image capturing devices such as cameras and medical scanners as one of the 10 Emerging Technologies 2007 [3].

The ground breaking results from recent publications in this field can have a huge impact on current ‘known facts’ in information theory, as well as in signal processing and (multimedia) communication technologies. Since this topic started evolving over the last few years it was mostly covered on a mathematical basis. The application point of view from engineering side is still underpresented and will be target for research.

The trend in recent hardware system designs, especially when they are battery driven (e.g., notebooks, cellular phones or handhelds), is to operate the different components of the system (RF circuits, baseband processor, etc. in case of a cellular phone) with different supply voltages, in order to achieve optimum performance and high power efficiency. The task of a DC-DC converter is to produce this variety of required supply voltages by decreasing or increasing the voltage level offered by the source power supply (e.g., a battery). The challenging part is to perform this voltage conversions as power efficient as possible.

Traditionally, such DC-DC converters were implemented as analog circuits, but recently more and more functionality is implemented by digital circuitry. This offers more flexibility on the one hand, and offers the opportunity to integrate more complex, maybe even adaptable control logic, on the other hand.

The project which is done in cooperation with Infineon Villach aims to investigate and also develop a PWM-based digital control logic for future DC-DC converters, with the goal to reduce the overall power consumption.

The Figure above shows a high level schematic of a digitally controlled DC-DC converter is depicted. As a first step, the analog components of the DC-DC converter must be known in order to control the circuit in an optimized fashion. It might also be necessary to investigate adaptable control logic, which autonomously can estimate the parameters of the external elements (tolerances of coils, capacitors, etc.).

With a more accurate knowledge of the control path, the control process can be optimized. Furthermore, power savings can also be achieved by optimizing the transient effects when turning the circuit on and off. This is a common task in many modern systems, where only active hardware blocks are powered on. The research results shall be verified by simulations and by measurements on real prototype hardware.
Near Field Communication (NFC) is a new, short-range wireless connectivity technology that evolved from a combination of existing contactless identification and interconnection technologies. Products with built-in NFC will dramatically simplify the way consumer devices interact with one another.

NFC technology is currently mainly aimed at being used with mobile phones. Though, plenty of applications will be possible such as:

- Mobile ticketing in public transport - an extension of the existing contactless infrastructure.
- Mobile Payment - the mobile phone acts as a debit credit payment card.
- Smart poster - the mobile phone is used to read RFID tags on outdoor billboards in order to get info on the move.
- Bluetooth pairing - in the future pairing of Bluetooth 2.1 devices with NFC support will be as easy as bringing them close together and accepting the pairing. The process of activating Bluetooth on both sides, searching, waiting, pairing and authorization will be replaced by a simple "touch" of the mobile phones.
- Electronic passport (containing finger prints, photos, information for identification by the human iris, etc.)

Operating at 13.56 MHz and transferring data at up to 424 Kbits/second, NFC provides intuitive, simple, and safe communication between electronic devices. NFC is both a “read” and “write” technology.

Communication between two NFC-compatible devices occurs when they are brought together within about 10 centimeters range.

There are three main use cases for NFC:

- card emulation: the NFC device behaves like an existing contactless card
- reader mode: the NFC device is active and reads a passive RFID tag, for example for interactive advertising
- P2P mode: two NFC devices are communicating together and exchanging information.

The underlying layers of NFC technology follow universally implemented ISO, ECMA, and ETSI standards. Because the transmission range is so short, NFC-enabled transactions are inherently secure. Also, physical proximity of the device to the reader gives users the reassurance of being in control of the process.

The goal of this research project is to push the transmission rates up to several tenth of Mb/s. The project is done in co-operation with NXP Semiconductors Austria GmbH. Combining circuit design knowledge in the field of RFID with modern communication technology promises to reach the aimed high goals.
The research portfolio of the Mobile Systems Group is depicted on the right side. We perform research on networking issues in mobile and wireless systems. This includes the design of algorithms and protocols, contributions to networking theory, network architectures, and modelling and simulation aspects. Our goal is to enable new applications of wireless communication that go beyond classical applications of cellular networks and wireless local area networks.

Current research activities and projects are as follows:

- **Cooperative Spatial Diversity in Ad Hoc Networks.** A well-known technique to improve the robustness of wireless transmission in wireless cellular networks is spatial diversity. In this project, we apply spatial diversity to wireless multihop networks and investigate new techniques for packet transport based on this concept. Our main focus is to design and assess protocols for relay selection, packet combining, and medium access control. The two-year project is funded by Orange Labs, France.

- **Distributed Slot Synchronization in Radio Networks.** We develop a distributed algorithm for slot synchronization suited for ad hoc networks. Our approach has been inspired from biology, from the synchronous flashing of fireflies. We noticed that a one-to-one transfer of the well-known firefly synchronization to wireless networks is infeasible, due to some characteristics of radio communications. We thus invented significant modifications, making the synchronization converge in multihop radio networks. Our scheme achieves high synchrony rates and a synchronization accuracy only limited by the propagation delay. The work is done in very close cooperation with DoCoMo Euro-Labs, Munich, Germany.

- **Mobility in Sparse Wireless Networks** (Acronym: SPARSE). The goal of this project is to create a framework for modeling sparsely connected wireless networks with inhomogeneous node distributions and to design and assess protocols that exploit inherent node mobility for packet delivery is such networks. The project is partly funded by Soongsil University, Seoul, Korea within a large Korean research project.

- **Network Coding.** Network coding is a new, disruptive approach for transporting information through a network. Rather than routing the information in form of dedicated packets, it enables intermediate nodes to combine pieces of information coming from different sources. Our goal is to investigate the impact of the network topology on selected network coding techniques as well as contribute to practical protocol aspects of network coding when being applied in wireless networks. The work is done in cooperation with the University of Porto, Portugal.
Cooperative Spatial Diversity in Ad Hoc Networks
Helmut Adam and Christian Bettstetter

The mobile radio environment is characterized by large-scale and small-scale fading. Large-scale fading is caused by a distance-dependent path loss and shadowing. Small-scale fading is caused by multipath propagation, i.e., radio waves are reflected and scattered at obstacles in the environment, resulting in multiple rays that find different ways to the receiver.

At the receiver, these multiple rays superimpose, constructively or destructively. Since the device is in general mobile and the environment changes over time due to mobility of obstacles, these fading effects are time variant. This leads to rapid fluctuations of the received signal-to-noise ratio (SNR) and the delay of the different signal paths. If a mobile device moves only a small distance, it may get from a deep “fading hole” to perfect signal reception. Indeed, the minima and maxima of the received SNR are very close to each other and are only separated by some fractions of the wavelength. This is the reason why multipath fading is called small-scale fading.

The newest mitigation technique to combat the effects of small scale fading is cooperative diversity which is based on the concepts of spatial diversity in combination with cooperation. In traditional cellular networks, spatial diversity techniques have mainly been investigated in a way that several antenna elements are mounted on a single base station or device.

This is not always practically feasible on small mobile devices. Indeed the concept of spatial diversity is very appealing in ad hoc networks: The wireless medium is a broadcast medium and thus devices adjacent to a communicating device pair overhear their transmission anyway.

Why should these devices not help to relay packets in a cooperative manner?

The basic building block of this emerging area is the “relay channel”: A source node transmits a message to a destination; a third node overhears this transmission and forwards (relays) the message to the destination; finally, the destination combines the two received messages to improve decoding.

The main goal of this research activity is to design and evaluate algorithms for exploiting cooperative spatial diversity in ad hoc networks and to analyze fundamental limits of cooperative spatial diversity in multihop environments.

Some of the results achieved so far:

• Design and implementation of a simulation tool to test and evaluate cooperative diversity schemas from a protocol perspective.

• Analysis and implementation of a schema called “Simple Packet Combining” on wireless sensor nodes (internship’s project) – During this project it got evident that cooperative diversity is clearly a cross layer task.

• Comparison of different relay selection protocols – the relay selection for cooperative diversity is a key issue. So far all discovered solutions are suboptimal. The most promising one is called “Opportunistic Relay Selection”.

• Analysis and implementation of “Opportunistic Relay Selection” in the simulation tool.

• Improvement of the basic “Opportunistic Relay Selection” protocol in terms of energy efficiency – by assessing the channel and deciding on the reasonability of cooperation a formidable amount of energy can be saved while keeping the overall outage performance constant.
The mobility of nodes is usually being experienced as a challenge and handicap in wireless mobile networks. Recently, however, researchers found instances in which mobility is actually helpful for the network operation and can yield benefits. Therefore, the notion of "exploiting mobility" gained interest in the literature.

Our intention is to investigate possibilities to exploit the inherent mobility in wireless networks. We believe that this would be especially useful in sparsely connected networks which can also be found in practice. Hence, we focus on such types of networks.

Work done so far

In order to be able to accurately simulate new and existing protocols in sparse wireless networks we found it necessary to investigate the initial spatial distribution of the nodes and how to model the mobility of them. The initial spatial distribution defines where on the simulation area nodes are placed. While many researchers use the uniform distribution this is not appropriate for sparse networks where nodes tend to form clusters. That is why we have devised our own inhomogeneous distribution and derived its most useful stochastic properties so that other researchers might also use our inhomogeneous distribution.

We have also developed an objective measure to assess the inhomogeneity of any spatial distribution. Using this measure we can automatically generate random distributions with similar inhomogeneity as a real location trace of a sparse network. We have also performed an online survey to find out how the objective measure corresponds to the human perception of inhomogeneity and how different view-angles on the same distribution affect the human perception.

Now that we have an appropriate initial spatial distribution and allow the nodes to move it is essential to avoid that the inhomogeneity gets lost and the distribution converges to a uniform distribution or some other extreme case. We found that existing mobility models cannot maintain the inhomogeneity and therefore started developing a mobility model that does. A paper on this topic is currently in preparation and the mobility model is being simulated and fine-tuned using a self-written mobility simulator and our inhomogeneity measure.

Outlook

After having established a profound basis for the simulation of the protocols in sparse wireless networks the next years will be focussed on actual protocols that try to exploit the inherent mobility. The applications we are currently considering are mobility assisted flooding and keeping routes stable by taking the mobility into account when routes are established or having mobile entities move to avoid a break-up. These protocols will be devised, implemented, and simulated in our mobility simulator. The long-term objective is to create a real mobile test platform based on small and cheap mobile robots on which the protocols can be evaluated in the real world.
The fundamental task of communication networks is to deliver information from source nodes to destination nodes possibly via some intermediate nodes. This task should be fulfilled in a reliable and resource-efficient manner. In packet-switched networks, the information is transported in form of packets whose payload represents the information bits that are sent by a source node. A packet is routed throughout the communication network from the source to the destination much in the same manner as a car moves on a road network from the starting point to the destination point. Independent packets in the network are kept separate; routers simply store and forward the packets. This basic assumption is common to all of today’s communication networks, among them the worldwide Internet and cellular wireless networks.

Recently, the concept of “network coding”, a new and completely different paradigm for transporting information through a network was born. This concept is based on the simple but important observation that the act of combining different packets in an intermediate node can yield significant advantages, leading to higher end-to-end throughput, improvements in energy efficiency, increased robustness and security.

Our work addresses the following fields:

- Visualization of network coding
- Network coded flooding: comparison of established flooding techniques with network coding
- Implementation and protocol aspects of network coding in wireless systems
- Existence of network codes with special properties; size of the fields used for coding

Some of the results achieved so far are as follows:

- Development of a network coding visualization tool
- Development of a simulation tool that allows experimentation and analysis of networking algorithms in dynamic networks
- Analytical analysis and simulation of different approaches to flooding with and without network coding in random graphs
- Simulation results of network coding integrated into DSR routing algorithm
**Pervasive Computing** is the trend towards increasingly ubiquitous, connected computing devices in the environment. This trend has been leveraged by a convergence of advanced technologies such as embedded computing, wireless communication and sophisticated sensing. Pervasive computing devices are not personal computers as we tend to think of them, but very tiny – even invisible – devices, either mobile or embedded in almost any type of object imaginable.

**Research overview**

Our research is based on the technological aspects of pervasive computing, i.e., we conduct basic and technology-oriented research towards networked and embedded systems. Within the comprehensive and interdisciplinary fields of pervasive computing we focus on the research areas sensor fusion, embedded computing and distributed systems and demonstrate the findings in application areas such as traffic monitoring and intelligent environments. Thus, our work fits very well to the research portfolio of the other research groups at our institute. The work on distributed smart cameras exemplifies very well our research activities. In this strategic research area we focus on several aspects of distributed smart cameras such as distributed resource management, collaborative image processing and sensor fusion. We develop prototypes of distributed smart camera systems and apply them in case studies such as traffic monitoring and security. Our research group was organizing the “First ACM/IEEE International Conference on Distributed Smart Cameras” which was held in Vienna in September 2007.

**Partners and Funding**

Our research is conducted in close cooperation with national and international partners both in academia as well as in industry. National partners include Graz University of Technology, the Austrian Research Centers, EFKON AG Graz and the Carinthian Tech Research, Villach. At the international level, we collaborate among others with Georgia Institute of Technology, Stanford University and NXP Research. Our research has been supported by companies such as Texas Instruments and Altera. We are leading research projects on “Autonomous Traffic Monitoring by Embedded Vision” and “Embedded Multi-Sensor Fusion” – both funded by the Austrian Research Promotion Agency.
Pervasive Smart Cameras
Previous developments in the areas of communication technology and embedded systems lead to smaller, more powerful and less power-consuming system architectures. Combining these developments with the emerging technology of smart cameras leads to smaller and cheaper intelligent camera nodes. Integrating a large number of radio enabled cameras into a network, makes the idea of a pervasive smart camera realizable. The approach behind is to distribute all the smartness of an image sensor network over a high number of sensors, to make the system acting more autonomously, and therefore making it usable for a wider range of applications.

Vision Sensor Architecture
Designing and developing a versatile architecture for a pervasive smart camera network in general, and an image sensor node in particular, is rather challenging. The capabilities of the nodes must range from distributed vision, self-calibration and self-organization to maintenance-free operation and wireless communication. By using different types of nodes in the network, low-level and high-level data processing can be performed on different architectures. We have proposed an architecture for a pervasive smart camera network, consisting of two layers of nodes with a well-defined scope of functions.

Distributed Embedded Vision
The main power of the pervasive smart camera approach is the large number of small and cheap vision sensors. Scene information from large areas and from different points of view can be simultaneously grabbed. One challenge in enabling vision on these sensors is to cope with the large amount of image data while taking care of the power consumption and the limited processing and communication capabilities of the embedded system. Adapting well-known vision processes to work in real-time, potentially on special-purpose hardware, and to separate between in-node and in-network processing with respect to communication overhead and information benefit, are the main goals to achieve.

Prototyping
The evaluation environment used for prototyping the vision sensor nodes involves different technologies. Besides general-purpose workstations in combination with high-level languages, special-purpose hardware is used.
Digital signal processors (DSPs) are widely used in smart cameras for doing low-level image processing and analysis tasks. For evaluating both, local and distributed image processing, we use DSP developer kits provided by Texas Instruments. Currently different approaches for object classification and object tracking are implemented and evaluated.
Furthermore the prototype of a wireless smart camera, which combines an SIMD image processor with a low-end general purpose processor, is provided by NXP Research. The image processor can execute low-level operations on half VGA lines in a single cycle. The special character of the parallel architecture is currently evaluated by implementing methods for face detection. Further work using this platform deals with the integration of the cameras into a low-range wireless network, and with the evaluation of algorithms for distributed object classification and object tracking.
On-line Embedded Multi-Sensor Data Fusion  
Andreas Starzacher and Bernhard Rinner

**Motivation**
The world will witness a tremendous increase in the number of vehicles in the near future. Future traffic monitoring systems will therefore play an important role to improve the throughput and safety of roads. Current monitoring systems capture (vision-, acoustic-, laser-based) traffic data from a large sensory network. The overall aim of this research is to improve the quality of this traffic data by fusing the data captured from the multiple and heterogeneous sensors.

**Field of Research**
Multi-sensor data fusion (MSDF) is the process of combining homogeneous as well as heterogeneous data coming from several different sensors. There are significant advantages over single source data as a result of this process such as improved overall system reliability and robustness, reduced uncertainty, extended temporal and spatial coverage, increased confidence, improved detection/classification.

This research is performed as part of the “Autonomous Traffic Monitoring by Embedded Vision (EVis)” project which is a collaboration among Graz University of Technology, EFKON AG and Klagenfurt University and is funded by the FIT-IT[visual computing] program. (For more information see http://pervasive.uniklu.ac.at/evis).

**Current / Future Work**
The initial phase of this project has been dominated by an intensive literature research in order to achieve a comprehensive overview of state-of-the-art MSDF algorithms. The focus has been particularly directed to the fields of machine learning and embedded computing. As fusion can be performed at different levels of abstraction, algorithms for each of these levels have been investigated. Special focus has been laid on inference and classification methods which are promising for resource-constrained embedded systems. An early prototype of an embedded fusion architecture has been developed. In this layered fusion architecture, each layer is responsible for a very specific task during the whole distributed fusion process [1]. Besides finding novel ways of combining data exploiting spatio-temporal relations in traffic monitoring environments, the tasks for each individual layer within the fusion architecture need to be defined precisely and implemented.

In the future we will focus on enhancing our prototype architecture evaluating the different fusion algorithms our architecture and demonstrating our approach and several real-world scenarios. We identified tracking cars along intersections as our first case study.

**Publications**
Smart Camera Networks

Smart cameras are characterized by the fact that they provide significant amounts of computational capabilities for video and image processing and analysis. The main benefit of this approach is that video data must not be streamed to a centralized processing facility but only detected events are reported to consumers of the information. Most of the proposed camera systems rely on fixed infrastructure in terms of power supply and wired networking. Additionally, these systems are deployed in a static manner requiring precise calibration by experts. With the advances in the field of wireless sensor networks it becomes feasible to design and implement camera systems that no longer require a fixed infrastructure. This opens up the possibility for ad-hoc deployment of camera networks where no infrastructure is available or would be too expensive or complicated to establish.

Applications and Research Questions

Potential application scenarios are short term phenomena like crowd monitoring at sporting events taking place at a non regular basis or at varying locations as well as disaster management and relief operations which can not be planned ahead of time. A central requirement for all these application scenarios is the capability to deploy a significant number of nodes in an ad-hoc manner by non-expert users. This directly leads to a number of research questions that need to be answered when designing and implementing such a system. Selected questions are e.g. how to localize nodes and establish clusters and neighborhood relationships with respect to overlapping or adjacent fields of view of the cameras. Further questions are how to efficiently deal with the addition and removal of nodes and, related to that, the dynamic assignment of roles to individual nodes.

Visual Sensor Network Architecture

As a first step to approach the problem, a potential architecture for a distributed wireless vision sensor network has been defined. The design is divided into two layers to reduce the complexity of system deployment and management. The first layer of nodes consists of wireless smart cameras providing specialized image processing functionality and low range networking capabilities. The second layer is comprised of fewer general purpose nodes which, in addition to the low range networking technology feature mid-range wireless networking. This second layer is designed to manage the adjacent cameras within networking range. During deployment phase the general purpose nodes act as coordinators for localization, clustering and configuration. Once the system is operational, the general purpose nodes provide a wireless backbone based on their mid-range networking capabilities and additionally run the execution environment for the actual applications that rely on information delivered by the camera nodes. Important questions to be answered are how to efficiently deploy user applications into such a network and how to extract and aggregate relevant data from the nodes to be delivered to the users.

The next step will be the implementation of a prototype system based SUN Spots wireless sensor nodes and the WiCA wireless smart camera.
Lakeside Labs

All professors of the institute were intensively involved into the development of Lakeside Labs—a new research center on information and communication technologies affiliated with the university.
Lakeside Labs in a Nutshell

Lakeside Labs is a new independent research center on information and communication technologies. Research at Lakeside Labs will develop concepts, technologies and algorithms for self-organizing networked systems.

The lab is mainly funded by the European Union, funds from the region of Carinthia, and the state of Austria. The total financial resources of the lab comprise ~3.5 Million EUR/year; the human resources are 40 PY/year; both for a period of 5 years.

The lab is affiliated with the University of Klagenfurt and should serve as an “incubator” for the new ICT institutes and technically-oriented INF institutes of the university, which contribute 1.5 million EUR of the resources as in-kind contributions.

Research Area

Cell phone, Internet and wireless LAN: Information and communication technology has made its mark during the past decade. Scientists at Lakeside Labs will take a further step towards the future: They are researching into ‘self-organizing networked systems’ and their practical usage. Mobile devices, such as cell phones and notebooks, have become our constant companions both at work and in our leisure time.

We converse with our business partners whilst traveling, and send electronic photos home from our holidays. We surf the Internet via fast, wireless connections at work, on the campus and more and more frequently at home. Mobile and multimedia communication technology is all around us.

However, the expectations of research and industry from this technology are considerably higher: Not only are cell phones and computers being interconnected, but more and more everyday objects of which we would not immediately expect this. The latter form an ‘Internet of things’ that is intended to be of assistance to people in their daily lives.

For instance, the wireless connection of cars can warn of accidents and traffic jams. For such, technically and economically extremely interesting, visions to become reality, new technologies are required that enable a spontaneous and self-organizing networking of devices – if possible, independent of a network infrastructure. Moreover, the networked devices interact actively with their environment in that they record information, for example, using sensors and cameras, and influence their environment by means of actuators. The devices are quasi embedded into their environment, where they fulfill specific tasks and form the interface between the real and virtual world.

In this context, Lakeside Labs is concerned with information and communication technologies for ‘self-organizing networked systems’, the focal point of the research being techniques, technologies and services for such versatile, dynamic networks. For example, new algorithms and protocols for energy-saving radio transmission are being developed. “We are working on basic concepts for the design and modeling of self-organizing technical systems,” explains Christian Bettstetter.
In addition to technical development, one main aspect is human usage. Two specific application areas have been selected in which the concepts and technologies that have been developed are to be implemented as prototypes and tested. They comprise ‘automotive safety’ and ‘disaster management’. In these two areas, the efficient implementation of the new technologies is being tested in cooperation with relevant companies and organizations.

**Cars that can look around corners**

‘In the year 2000 alone, 40,000 people were killed and 1.7 million people injured in car accidents on the streets of the European Union.

These victims and the indirect costs involved make these streets a dangerous and expensive transport route’, according to Professor Kyandoghere Kyamakya, who holds the Chair in Traffic Management at the University of Klagenfurt. Driver assistance systems, such as ABS or EPS, already help to alleviate one of the causes of these accidents – human fatigue. Novel applications involve both pedestrians and traffic signs.

However, these developments have their limitations. Just like people, they cannot see around corners and obstacles. ‘This is where the idea of interaction and cooperation between cars via self-organizing wireless networks is effective. Cars that can receive and interpret information from their environment, and exchange this data with other cars in their vicinity, can recognize and avoid dangerous situations in advance’, says Kyamakya.

**Technology that saves lives**

The NES institute will mainly contribute to the second application area: disaster management. For various reasons, the climate change the incidence of floods, avalanches and devastating storms is increasing. There are also earthquakes and threats by human beings, such as fires and terrorist attacks.

Information and communication technology plays a central part in the warning and management of catastrophes. Thus areas and regions can be surveyed, for example, with the aid of wireless sensor networks, and people warned of storms, floods and avalanches in sufficient time.

The emergency services also profit from spontaneous wireless networking: Firefighters are being equipped with networked cameras and displays. Earthquake relief workers communicate even when the entire network infrastructure has been destroyed.

**Self-organization: a ubiquitous phenomenon**

Research into self-organizing networked systems not only has technical and user-oriented aims, it also enables a high degree of interdisciplinary. We encounter self-organizing systems on an almost daily basis: In the formations of swarms of fish and migratory birds, the interplay of termites when they build their hills, or the activity of body cells during the healing of wounds. In many areas of nature, single individuals or organ-
isms work together without central coordination, but in perfect harmony. Large areas of the economy have already been functioning for many years according to this paradigm.

In self-organizing systems, the instances involved form decisions based on limited local knowledge. This leads to a desired emergent behavior of the entire system. Naturally self-organizing systems also possess many characteristics that are of value in technical systems: They are flexible and reliable, very adaptable and can be extended at any time. It is therefore no wonder that technical science has now discovered these and would like to implement them wherever centrally coordinated systems reach their limitations.

‘The economic future of the area of self-organization is rated very positively’, says Professor Hermann Kopetz of the Technical University of Vienna. ‘At present the limitations of the complexity of centrally planned systems is visible in many places. Through the use of the principles of self-organization we hope to better control the ever-increasing complexity of large systems, and to significantly increase their reliability.’
Hermann De Meer (Universität Passau)
Towards Modelling of Self-Organizing Systems

Self-organizing systems are typically characterized as being decentrally self-managed based on autonomous components. Typically, there is also a reference to complex systems and an emergence of global structure based on local interactions between components. Some exchanges of information with the environment that may even lead to an evolutionary change. While broad consensus may be achievable about the attractiveness of such a concept for characterizing complex systems, there is a clear lack of formal methods and modelling techniques as a prerequisite for a constructive usage. It is our goal to investigate mathematical modelling techniques for a more comprehensive description of the processes triggering self-organization towards the ultimate purpose of algorithmic and constructive applicability in a more technical setting.

Robert Vilzmann (TU München)
Medienzugriff mal anders: Mehrnutzerdetektion in selbstorganisierenden drahtlosen Netzen


Joachim Hagenauer (TU München)
Informationstheorie und Genetik

Publications

**Journal, book, and magazine articles**


**Conference Papers**


Poster Presentations and Short Papers


• C. Bettstetter: Research and Teaching at Klagenfurt’s Mobile Systems Group. Invited talk at Soongsil University, Seoul, Korea, Feb. 2007.


• C. Bettstetter: Paradigmen zur Vernetzung der Dinge: Über Relays, XORs und Glühwürmchen. Inaugural lecture at the University of Klagenfurt, Austria, Sept. 2007.


• B. Rinner: Was macht Kameras intelligent? Tag der Forschung, University of Klagenfurt, Nov. 2007.

• B. Rinner: Distributed Smart Cameras. Informatik Kolloquium, University of Paderborn, Nov. 2007.

Scientific Appointments

Editorial Board Member

- Christian Bettstetter is Member of the Editorial board of "ACM Mobile Computing and Communications Review (MC2R)".

Conference Chairs

- Bernhard Rinner served as general conference co-chair of the „ACM/IEEE Conference on Distributed Smart Cameras (ICDSC-07)“, Vienna, Sept. 2007.

Steering Boards

- Christian Bettstetter is Austrian representative and member of the steering board of the European Science Foundation (ESF)-funded project "Middleware for Network Eccentric and Mobile Applications (MiNEMA)".

Guest Editor

- Christian Bettstetter was guest editor of a Special issue on 'Cooperation in Wireless Networks' in Springer Wireless Personal Communications.
- Bernhard Rinner is chief editor of a special issue on "Distributed Smart Cameras" in the Proceedings of the IEEE.
- Bernhard Rinner is guest editor of a special issue on "Distributed Processing in Vision Networks" in the IEEE Journal on Selected Topics in Signal Processing.
- Bernhard Rinner is guest editor of a special issue on "Human-Centric Applications of Distributed Camera Networks" in the EURASIP Journal on Image and Video Processing.
Program Committee Memberships

Christian Bettstetter:

- IEEE Intern. Conf. on Communications (ICC), Beijing, China, May 19-23, 2008.

Wilfried Elmenreich:

- IEEE International Conference on Industrial Informatics (INDIN), Vienna, Austria, July 2007
- International Symposium on Logistics and Industrial Informatics (LINDI), Wildau, Germany, Sept. 2007
- Intelligent Systems Design and Applications (ISDA), Rio de Janeiro, Brazil, Oct. 2007
- Workshop on Intelligent Solutions in Embedded Systems (WISES), Madrid, Spain, June 2007

Mario Huemer:

- European Conf. on Wireless Technology (ECWT), Munich, Germany, Oct. 2007
- Intern. Conf. on Wireless Information Networks and Systems (WINSYS), Barcelona, Spain, July 2007.
- Intern. Conf. on Computer Aided System Theory (EUROCAST), Las Palmas, Spain, Feb. 2007.

Bernhard Rinner:

- IEEE International Conference on Intelligent Environments (IE), Ulm, Germany, Sept. 2007
- Workshop on Intelligent Solutions in Embedded Systems (WISES), Madrid, Spain, June 2007
- International Workshop on ITS for Ubiquitous Roads (UBIROADS), Marrakech, Morocco, June 2007
Reviewing Activities

Christian Bettstetter served as reviewer for:

- IEEE Journal on Selected Areas in Communications (JSAC)
- IEEE Transactions on Mobile Computing
- European Transactions on Telecommunications (ETT)
- the European Commission in the FP6 projects ACE, ENABLE, FIREWORKS, POPEYE, and WIP.

Wilfried Elmenreich served as reviewer for:

- IEEE Transactions on Industrial Informatics
- IEEE Journal of Selected Topics in Signal Processing

Michael Gyarmati served as reviewer for:

- IEEE Transactions on Mobile Computing

Mario Huemer served as a reviewer for

- Center for Innovation and Technology (ZIT: Zentrum für Innovation und Technologie), a subsidiary of Wiener Wirtschaftsförderungsfonds - WWFF (Vienna Business Agency).

- John Wiley & Sons
- IEEE Communication Letters
- International Journal of Electronics and Communications (AEÜ)
- Proceedings of the European Microwave Association (Proceedings EUMA, the Journal of the European Microwave Association)

Bernhard Rinner served as reviewer for

- IEEE Computer
- EURASIP Journal on Embedded Systems
- IEEE Transactions for Circuits and Systems
- Machine Vision and Applications Journal
- IEEE Journal on Selected Topics in Signal Processing
- ACM Transactions on Embedded Computing Systems
PhD Examination Activities

**Completed PhD Theses**


**External Doctoral Students**

*Mario Huemer* supervises the following doctoral students at the University of Erlangen-Nuremberg, Germany:

- Dipl.-Ing. Tufik Buzid
- Dipl.-Ing. (FH) Andreas Gstöttner
- Dipl.-Ing. (FH) Ralf Mosshammer

*Bernhard Rinner* supervises the following doctoral students at Graz University of Technology:

- Dipl.-Ing. Milan Jovanovic
- Dipl.-Ing. Andreas Klausner
- Dipl.-Ing. Markus Quaritsch
- Dipl.-Ing. Allan Tengg

**Evaluation of doctoral theses**

- *Christian Bettstetter* served as an evaluator and examiner of the doctoral thesis "performance studies of wireless multihop networks" (Henri Koskinen) at the Helsinki University of Technology, Finland.

- *Mario Huemer* served as an evaluator and examiner of the doctoral thesis “RF-Impairments in an HSDPA and LTE Compliant Receiver Front-End” (Rainer Stuhlberger) at the University of Linz, Austria. Defense: Linz, 22.11.2007.
In the winter semester 2006/07, the Institute of Networked and Embedded Systems (NES) and the Institute of Smart System Technologies (IST) launched a bachelor program “Informationstechnik” and a new master program “Information Technology”.

The new programs complement the already existing programs Informatics, Technical Mathematics, and Information Management that have been offered by the Department for several years.

At the time of writing this report, almost 100 students are enrolled in one of the new programs.

**Bachelor Program**

The bachelor program has a duration of six semesters with a total of 180 ECTS credits and is taught in German.

The courses in the first four semesters in the bachelor program teach the fundamentals of electrical engineering, informatics, and engineering mathematics. The core modules are as follows:

- Circuits and Electronics
- Signals and Systems
- Computer, Network, and Control Engineering
- Informatics and Software Engineering
- Engineering Mathematics

Each of these modules consists of compulsory lectures and exercises. Furthermore, a comprehensive laboratory course is offered.

In the last two semesters of the undergraduate program, students have the possibility to choose courses from application-oriented areas of information and communication technology.

The acquired knowledge is trained in seminars, bachelor theses, and in either a team project or an internship. Last but not least, students can enroll in elective courses to broaden one’s mind and to train soft skills.

Upon completion of the program, students obtain the academic degree “Bachelor of Science (BSc)”.  

**Master Program**

The graduate program provides the scientific qualifications necessary for a career in the development and operation of modern information and communication technologies. It has a duration of four semesters with a total of 120 ECTS credits and is taught in English.

Students can choose one of six areas as their major field of specialization. The following areas are available:

- Mobile and Wireless Systems
- Intelligent Transportation Systems
- Pervasive Computing
- Media Engineering
- Embedded Systems
- Applied Mechatronics

In addition to this technical specialization, the program also enables students to choose a methodological specialization. The following so-called “tracks” are offered:

- Research Track
- Entrepreneurship Track
- Industrial Track

With this design concept, students have the flexibility to concentrate on the area in which they later wish to work.

The academic degree upon completion of the program is Diplomingenieur/in (Dipl.-Ing.).

A description of both programs can be found at http://tfb.uni-klu.ac.at.
The institute’s teaching activities are centered around the bachelor and master program “Information Technology” and the master program “Informatics”.

In the year 2007, several new lectures, exercises, and lab courses have been developed and offered for the first time. The institute covered most technically-oriented mandatory courses in the bachelor program Information Technology and offered a variety of courses in the master program. The current teaching portfolio comprises the following courses as well as seminars, research seminars, and privatissima.

**Bachelor Courses offered by NES in 2007**

<table>
<thead>
<tr>
<th>Sem</th>
<th>Title</th>
<th>Lecture</th>
<th>Hours</th>
<th>Exercises/Lab</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Einführung in das Studium Informationstechnik und aktuelle Fallstudien aus der Praxis</td>
<td>Bettstetter</td>
<td>1</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Elektrotechnische und physikalische Grundlagen der Informationstechnik</td>
<td>Bettstetter</td>
<td>2</td>
<td>Adam</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Schaltungstechnik</td>
<td>Huemer</td>
<td>2</td>
<td>Schlechter</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Signaldarstellung und -übertragung</td>
<td>Huemer</td>
<td>2</td>
<td>Onic, Gyarmati</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Entwurf digitaler Schaltungen</td>
<td>Rinner</td>
<td>2</td>
<td>Winkler</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Digitale Signalverarbeitung</td>
<td>Huemer</td>
<td>2</td>
<td>Onic</td>
<td>2</td>
</tr>
</tbody>
</table>

**Master Courses offered by NES in 2007**

<table>
<thead>
<tr>
<th>Title</th>
<th>Lecture</th>
<th>Hours</th>
<th>Exercises/Lab</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Integrated Circuit Design and Simulation</td>
<td>Jungwirth</td>
<td>2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Communication Theory in Mobile Systems and Genetics</td>
<td>Hagenauer</td>
<td>2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Digital Signal Processors</td>
<td>Rinner</td>
<td>2</td>
<td>Schriebl</td>
<td>2</td>
</tr>
<tr>
<td>Embedded Communications</td>
<td>Huemer</td>
<td>2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Embedded Microcontroller Lab</td>
<td>—</td>
<td>Schlechter</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mobile and Wireless Systems I</td>
<td>Bettstetter</td>
<td>2</td>
<td>Schilcher</td>
<td>2</td>
</tr>
<tr>
<td>Mobile and Wireless Systems II</td>
<td>Bettstetter</td>
<td>2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Network Simulation Lab</td>
<td>—</td>
<td>Schilcher</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pervasive Computing</td>
<td>Rinner</td>
<td>2</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>RFID Topics</td>
<td>Neffe</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Processing Architectures for Embedded Applications</td>
<td>Huemer</td>
<td>2</td>
<td>Onic</td>
<td>2</td>
</tr>
</tbody>
</table>
Elektrotechnische und physikalische Grundlagen der Informationstechnik

Christian Bettstetter, Helmut Adam

Diese Einführungsvorlesung vermittelt die wichtigsten elektrophysikalischen Grundlagen der Informationstechnik. Dabei werden elektrische und magnetische Felder, der elektrische Strom, Entstehung elektromagnetischer Wellen, einfache Schaltungen und zeitlich veränderliche elektrodynamische Felder eingeführt.


Inhalt:

0 Fachliche Einführung und Überblick
  • Elektrotechnische Begriffe im täglichen Leben
  • Elektromagnetische Wechselwirkung von Ladungen
  • Physikalische Grundbegriffe
  • Mathematische Grundlagen
  • Literaturempfehlungen

1 Elektrostatik
  • Elektrische Ladung
  • Kräfte zwischen Ladungen
  • Elektrische Feldstärke
  • Arbeit, Spannung und Potential
  • Elektrische Erregung

2 Elektrischer Strom

Physikalische Grundlagen:
  • Stromstärke und Stromdichte
  • Ladungsträgerbewegung
  • Widerstand und Ohmsches Gesetz
  • Stromquelle: Die elektrische Batterie
DREHMOMENT EINER LEITERSCHLEIFE IM MAGNEFTFELD

Einfache Schaltungen:
- Kirchhoffsche Regeln
- Schaltungen mit Quellen und Widerständen
- Schaltungen mit Quellen, Widerständen und Kondensatoren

3 Magnetisches Feld
- Magnete
- Magnetisches Feld und Lorentzkraft
- Magnetischer Fluss und magnetische Erregung
- Ursachen von Magnetfeldern
  - Magnetfelder bewegter Ladungen
  - Magnetische Materialien
  - Magnetische Felder in Natur und Technik

4 Elektromagnetische Induktion
Physikalische Grundlagen
- Erzeugt ein Magnetfeld elektrischen Strom?
- Gesetze zur elektromagnetischen Induktion
- Zusammenhang zwischen E- und B-Feld

Elektrotechnik
- Induktivität und Spule
- Schaltungen mit Spulen: Ein- und Ausschaltvorgang
- Gegeninduktivität
- Technische Anwendungen der Induktion

5 Elektromagnetische Wellen
- Zusammenhang zw. E- und B-Feld (Teil 2)
- Entstehung elektromagnetischer Wellen
- Eigenschaften elektromagnetischer Wellen
- Maxwell’sche Gleichungen
- Elektromagnetische Wellen in Natur und Technik

Einer systematischen Betrachtung von Vierpolen folgen Transistorgrundschatlungen sowie die Möglichkeiten ihrer Arbeitspunkteinstellungen, die Analyse mit Hilfe von Ersatzschaltbildern und die Betrachtung ihres Frequenzverhaltens. Im nächsten Schritt werden Operationsverstärker sowie Operationsverstärker-Grundschatlungen untersucht.

Eine Anwendung von Operationsverstärkerschatlungen stellen die analogen Filter dar, die hier nicht nur analysiert sondern auch entworfen werden. Im abschließenden Kapitel werden Schaltungsvarianten für AD- und DA-Wandler für unterschiedliche Anwendungsgebiete vorgestellt.


Die Vorlesung wird durch einen Kurs ergänzt, in dem die in der Vorlesung gebrachten Inhalte anhand von Rechenbeispielen weiter vertieft und ergänzt werden, darüber hinaus haben die Studenten die Möglichkeit, ihr Wissen in Laboreinheiten praktisch anzuwenden.

**Inhalt:**

1. Komplexe Wechselstromrechnung (Lineare Netze im eingeschwungenen Zustand)
2. Ausgleichsvorgänge in linearen Netzen
3. Elektrische Leistung bei zeitlich veränderlichen Strömen und Spannungen
4. Lineare Vierpole
5. Transistor (Bipolar, FET) als Verstärker
6. Grundschaltungen mit mehreren Transistoren
7. Operationsverstärker und OPV-Grundschatlungen
8. Analog Filter: Analyse und Entwurf
9. AD- und DA-Wandler
Digitale Schaltungen spielen eine zentrale Rolle in der Informationstechnik. Sie stellen die Grundkomponenten in der Elektronik dar und sind daher in vielen Geräten des Alltagslebens zu finden.


Im folgenden Teil der Vorlesung werden fortgeschrittenen Technologien wie Register Transfers und der Aufbau von Speichерzellen besprochen. Abgeschlossen wird die Lehrveranstaltung mit der Betrachtungen des Aufbaus eines Mikroprozessors.

Die Vorlesung wird durch einen Kurs ergänzt, in dem die in der Vorlesung gebrachten Inhalte anhand von Rechenbeispielen weiter vertieft und ergänzt werden. Darüber hinaus werden die Studierenden im Rahmen des Kurses in die Grundlagen der Hardware-Beschreibungssprache VHDL eingeführt.

In Laboreinheiten haben die Studierenden die Möglichkeit dieses Wissen praktisch anzuwenden und grundlegende kombinatorische und sequentielle Schaltungen mit Hilfe von VHDL zu realisieren.

Inhalte:
1. Boolesche Algebra
2. Kombinatorische Logik
3. Schaltungsoptimierung
4. Sequentielle Logik
5. Speicherelemente
6. Registertransfer
7. Aufbau eines Mikroprozessors
8. Einführung in VHDL
Signaldarstellung und -übertragung

Mario Huemer, Alexander Onic, Michael Gyarmati


Die Vorlesung wird von einem Kurs begleitet. Im Kurs werden die in der Vorlesung behandelten Themengebiete mit Hilfe von Rechenbeispielen und mit Hilfe von Simulationsbeispielen in MATLAB/SIMULINK begleitet.


**Inhalte:**

1. Charakterisierung von Signalen

2. Analoge Signale (Fourier-Reihen, Fourier Transformation)

3. Analoge Systeme (Beschreibungsmethoden im Zeit- und Bildbereich)

4. Bandpasssignale- und Systeme

5. Zufallssignale und Reaktion von Systemen auf Zufallssignale

6. Analoge Modulationsverfahren (AM, FM, PM)

7. Grundlagen der digitalen Übertragung im Basisband

8. Grundlagen digitaler Modulationsverfahren (ASK, PSK, FSK, QAM, GMSK)
The lectures *Mobile and Wireless Systems 1 and 2* give a bottom-up introduction to the area of mobile and wireless communication systems. The main goal is to give a fundamental understanding of the principles behind wireless transmission and networking. Current technologies, such as UMTS and IEEE 802.11, are used as examples to explain these principles. Moreover, a whole chapter is dedicated to ad hoc and sensor networks. The lectures are complemented by group projects, whose results are discussed in class. A tutorial course with exercises is offered for the 1st lecture.

**Contents:**

1 Introduction and Overview
   - History of wireless communications
   - Different kinds of mobility
   - Overview and classification of wireless technologies
   - Key challenges in mobile and wireless systems

2 Antennas
   - Antenna types
   - Production of electromagnetic waves
   - Energy and power of electromagnetic waves
   - Radiation intensity, directivity, and gain
   - Antenna reception

3 Radio propagation and channel modeling

4 Coding, Modulation, and Duplexing
   - Representation of signals
   - Conversion from analog to digital
   - Channel coding (overview, block coding, convolutional coding, coding gain, channel coding in practice)
   - Digital modulation (overview, linear modula-
tion, coherent demodulation, modulation in practice, spread spectrum modulation)

• Duplexing

5 Multiple access and Cellular concept

• TDMA, FDMA, CDMA, SDMA
• Radio resource planning

6 Medium Access Control (MAC) protocols

• ALOHA
• Slotted ALOHA
• CSMA
• CSMA/CA
• Performance studies

7 Wireless LAN 802.11

8 Network Architecture and Mobility Protocols

• Architecture of cellular networks (General architecture, system components in GSM and UMTS,
• Mobility in cellular networks (Addressing and location updating, routing to mobile users, roaming and handover)
• Mobility in the Internet (addressing and mobility problem, autoconfiguration, device mobility with Mobile IP, service discovery)

9 Security in Mobile Networks

• Basics
• Security in GSM and UMTS

10 Ad Hoc and Sensor Networks

• Introduction and Applications
• Routing and Relaying
• Connectivity and capacity
• Wireless sensors

11 Economic, Health, and Social Aspects
This lecture course deals with the architecture of modern wireless communication systems. All main functional blocks of a mobile phone platform including the RF transceiver and the baseband processor are addressed.

A main focus is on the board level and on the chip level architectures. In the “Digital Baseband Transceiver” chapter important baseband algorithms (equalization, channel estimation, MIMO signal processing,…), possible implementation options, and corresponding complexity considerations are discussed. The “Analog Transceiver” chapter deals with the analog signal processing tasks of a wireless device, modern transmitter and receiver architectures are discussed and future trends on the way to Software Defined Radio architectures are presented.

Content:

• Introductory part
  - Equivalent baseband representation of passband signals
  - Basic principles of digital communications
  - Review of digital modulation techniques
  - The mobile radio channel

• Abstract Hardware View on a Mobile Phone Terminal Platform (Functional Blocks, Partitioning, Technology, Power)

• The Digital Baseband Transceiver
  - Single versus Multi Carrier Techniques (OFDM)
  - Channel Estimation
  - Equalization
  - MIMO Concepts

• The Analog Transceiver
  - Receiver Architectures
  - Transmitter Architectures
This lecture course deals with signal processing algorithms and with appropriate implementation architectures that focus on embedded applications. As a consequence low power consumption and low chip area is of great importance for the regarded architectures. The course starts with a repetition of important signal processing theory and algorithms (Sampling theorem, DFT, FFT, FIR and IIR-filters).

In the following the focus lies on implementation oriented issues like fixed point effects and architecture options. We will start with FFT architectures followed by architectures and design issues for fixed point FIR- and IIR-filters.

An old, but nowadays more and more important algorithm, the CORDIC algorithm, possible architectures and various applications of the CORDIC will be discussed in the next chapter. Next interpolation and decimation filters and possible low power implementation strategies are regarded. Another important issue in embedded applications is the digital signal generation. We will discuss different architectures for digital signal generators like sine wave generators. Finally we will regard architectures of modern DSPs and FPGAs for embedded applications.

In parallel a practical course will be offered, where the effects and architectures are studied with the help of MATLAB/SIMULINK simulations. The course starts with an introduction in MATLAB/SIMULINK and will then focus on practical issues on the appropriate topics covered in the lecture course.

Content:
- Review of signal processing basics
  - Characterization of digital signals
  - Sampling and reconstruction, sampling theorem
- DFT and FFT: theory and implementation architectures
- Digital filter basics
- Fixed point effects in digital filtering and efficient architectures
- CORDIC-algorithm: theory, architectures and applications
- Multirate signal processing (interpolation, decimation): theory and low power / low area HW-architectures
- Architectures for digital signal generators (DDS, Polynomial approximation, IIR-implementations, CORDIC)
- Architectures for digital signal processors
- FPGAs for signal processing
- Applications
Digital Signal Processors

Bernhard Rinner, Wolfgang Schriebl

Digital signal processors (DSPs) can be found in many devices such as mobile phones, PDAs and digital cameras. Their fields of application are ubiquitous ranging from control and measurement to audio and video processing. This lecture deals with the concepts of modern digital signal processors. It covers main topics of micro processor architectures, focuses on the characteristic features of DSP and presents up-to-date processors and development methods for DSP systems. Various case studies are presented during this lecture.

The lecture is complemented by a lab course, which applies the theoretical knowledge of digital signal processors to real-world problems. The students implement, under guidance of the lecturer, various digital filters for the C6416 DSP from Texas Instruments.

As programming a DSP implicates understanding the architecture and the concepts behind, many examples are implemented using both assembler language and C. The implementations are executed using developer starter kits, and are evaluated using the debugger and profiler. The lab is organized in units, which cover typical tasks from the areas of audio processing, image processing and optimization.

**Practical Units:**
- Audio processing: This unit deals with filter functions for amplification, reverberation, modulation and with FIR-filters (low-pass, band-pass, etc.). The functions are analysed using the waveform generator and music as a source, and the oscilloscope and headphones as evaluation instruments.
- Image processing: In this unit commonly used filter functions such as the threshold operation, median-filter and box-filters (Gauss and Sobel) are implemented. Furthermore, images and filters are analysed and improved by using histogram, adaptive threshold and histogram-equalization.
- Image compression: Image compressing in the frequency domain is the topic of this unit. An image compression chain using DCT/IDCT and huffman trees, similar to JPEG compression is realized and evaluated.
- Optimization: In this unit, the dot-product function is optimized step by step. Starting with sequential code the implementation is improved by filling delay slots, by using parallel instructions, by using world-wide optimization and by using software pipelining. The results of each optimization step are profiled and compared with the results of the compiler optimizations.

**Contents:**
1. Introduction to micro processors
2. From micro processors to DSPs
3. Development of DSP systems
4. Examples of DSPs
5. DSP programming
6. DSP applications and case studies
Embedded Microcontroller Lab

Thomas Schlechter

This course gives an introduction into the field of Embedded Microcontroller Systems. The participants of this course are expected to work on a given problem, which can be solved by a "machine".

During the course, the "machine" will, more or less completely, be implemented by the participants. The very interesting part of this course is, that circuit design skills (Hardware) as well as programming skills (C, Software) are necessary. The required knowledge will be taught during the course (basic knowledge excluded).

In order to keep hardware complexity as low as possible, a breadboard is provided to each group of the course. On this board several components of the "machine" are already implemented, only the electronic components have to be soldered in and additional peripheral circuits have to be designed. At the end of the course, the final board, built by the groups, can be taken home by the participants.

The software, implemented by each group, controls the microcontroller. C is consequently used for software implementation. Basic C-knowledge is expected from each participant at the beginning of the course.

Proceeding in the course, the participants will learn, how software and hardware work together, complement one another and build a complete system ("machine").

Contents:

1. Microcontroller ATmega32:
   - Structure
   - On-Chip-Periphery
   - Time Behaviour
   - Interaction of software and hardware

2. Development Environment:
   - Software Engineering on a Windows-System
   - Producing Code, executable on the Microcontroller
   - Programming Device, Data Transmission to the Microcontroller

3. Communications Interface:
   - Serial Asynchronous (RS232) and Synchronous (PS/2) Data Exchange
   - Parallel bidirectional Data Exchange via a bus system

4. Communication Protocols:
   - LCD Controller HD44780, PS/2 Keyboard
   - Hayes Command Set, GSM 07.07 and GSM 07.06
Most analog and mixed-signal circuit design today is done on a CMOS bulk process, using enhancement mode devices. This lecture will start from a basic understanding of components and circuits in analog circuit design.

A first step is to clearly delineate the difference between discrete and integrated MOSFET circuit design. Since integrated circuit design is strongly coupled with process technology the technology of devices used in analog design will be presented. Components and MOSFET amplifier configurations frequently used in analog design will be discussed using the concept of small-signal equivalent circuits. These stages serve as building blocks for more complex MOSFET amplifiers and allow the introduction of MOSFET integrated circuit design principles. Analytic calculation and numeric simulation of basic building blocks of amplifier configurations will be discussed. Finally, a deeper insight to complex circuits like oscillators, filters, mixers and phase-locked-loops will be given.

The importance of simulation in circuit design will be demonstrated by simulating the operation of several of the building block circuits using PSpice. Modifications in component parameters, loading of the input and output will emphasize the utility of simulation programs.

Contents:

1. Components in analog circuit design and its technology
2. MOSFET-Transistor
3. Basic building blocks in integrated amplifiers
4. Operational amplifier concepts
5. Signal generators / oscillators
6. Filters (SC-filters, SAW-filters, etc.)
7. Amplifiers (HF, CMOS, Bipolar, Wideband)
8. Mixers
9. PLL – Phase-Locked-Loops
10. Applications
This lecture is an introductory course into the field of communication theory.
In all modern communication systems information is being processed in multiple stages.

In this course two of these stages are discussed. The first one is the source coding stage which tries to minimize the information representation via optimal codes and compression. In the second treated stage channel coding is performed which makes the transmitted data more robust against distortions introduced by the transfer channel. At the beginning of this lecture the basics of information theory are revised. What is information, how to measure it and how to represent information are some of the answered questions.

In the source coding section the focus lies on lossless compression. Prefix free codes like Fano and Huffman are introduced. These codes rely on the knowledge of the statistics of the information. As an example of a universal source code the famous Lempel-Ziv algorithm (LZ77) is discussed. After source coding channel codes are introduced. First common expressions and parameters are introduced. Also the capacity of different channels is derived. Then different coding schemes starting from the simple one bit parity code to the modern Turbo Codes are discussed.

**Contents:**

1. Basics of Information Theory (entropy, mutual information, Kullback distance, binary symmetric channel model)
2. Shannon/Fano Code,
3. Hoffman Code,
4. Universal Source coding (LZ77)
5. Channel Coding (Channel Capacity, Hard/Soft Decision, Eb/N0, code rate, Shannon limit, Hamming Distance, Interleaving, Parity Code, Hamming Code)
6. Convolutional Code (Viterbi, Trellis, Trellis with soft decision, Punctured Codes)
7. Iterative decoding (log likelihood ration, soft bits, boxed-plus)
8. Turbo Codes
Radio Frequency Identification (RFID) Technology has got the attention of the public after the terror attacks in 2001 and the publications of the plans for the Future Store by the Metro group.

The terror attacks caused the usage of RFID for securing personal documents that are used to identify persons. The future store concentrated on the identification of objects to track goods within a large retail system. In both cases the used RFID devices are powered by an electromagnetic field but they have completely different requirements on operating distance, data storage, performance, security or pricing.

This lecture covers the main aspects of this technology. It will start with an introduction to RFID, an overview on the history and an outlook on this lecture. The first section describes the different RF communication technologies dependent on the carrier frequency. The second section covers the identification of objects and persons in detail. The third section describes the current RFID market with its privacy discussions and gives an outlook on new applications and required changes in technology. RFID prototyping environments are used to demonstrate the technology during the lecture. Integrated exercises support the understanding of RFID applications.

Contents:
1. Introduction and Overview
2. RFID Technology (Low Frequency 125kHz; High Frequency 13.56 MHz; Ultra High Frequency ~960MHz)
3. RFID Applications (Identification of Objects, Identification of Persons)
4. RFID Market (Current Situation, Applications and Market Volumes, Privacy)
5. Coming applications
6. Market volumes and pricing
7. Requirements on future technologies for RFID
Guest Lectures at External Institutions

Mario Huemer:


Bernhard Rinner:


First ACM / IEEE International Conference on Distributed Smart Cameras

The first ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC) was held in Vienna, Austria on September 25-28, 2007. The conference attracted 117 attendees mostly from North America and Europe who showed a strong interest in the intersection of computer vision, embedded computing, and distributed computing.

The conference started with a series of tutorials that introduced various topics that serve as background for distributed smart cameras. 22 technical papers were presented at the conference, covering a range of work. A series of poster/demo sessions were also held that presented 29 posters. Some work emphasized vision algorithms, while other work emphasized distributed embedded systems. A Ph.D. forum was also held that attracted presentations from 12 Ph.D. candidates.

Three plenary talks were given. Feng Zhao of Microsoft Research spoke on “Sensing platforms for World-Wide Sensor Web.” Mubarak Shah of the University of Central Florida spoke on “Video surveillance and monitoring using distributed cameras.” Wilfred Philips of the University of Ghent spoke on “Challenges for single- and multi-camera video processing.” The conference closed with a panel session titled “Distributed smart cameras: research toys or practical tools?”

Vienna offered a very pleasant environment for the conference. The conference itself was held at the University of Vienna in the heart of the city. The conference dinner included a tour of the city and of a local winery.

The second ICDSC will be held at Stanford University on September 7-11, 2008. The conference Web site is www.icdsc.org. We invite you to attend.

Der Grundstein wurde in Form einer großzügigen Spende im Rahmen des TI-Elite-Universitätsförderprogramms zur Ausrüstung eines Messlabors für Studierende und Forschungsassistenten im Bereich der an der Universität Klagenfurt neu eingerichteten Studienrichtung Informationstechnik gelegt. Das Labor soll den Studenten der Informationstechnik eine praxisnahe Ausbildung ermöglichen. Entwurf und Fertigstellung mikroelektronischer Schaltungen und eingebetteter Systeme stehen dabei im Mittelpunkt. Die Studierenden erlernen die theoretischen Grundlagen anschaulich und haben die Möglichkeit, aktuelle Spitzenforschung hautnah zu erleben. Versuche für Mobilfunkanwendungen (z.B. UMTS, HSDPA,...), drahtlose Internetanbindung, Multimediakommunikation sowie Grundlagen der Elektrotechnik sind nur ein kleiner Ausschnitt der sich neu bietenden Möglichkeiten.


Quelle: Presse&Medien | Universität Klagenfurt
Events

Microdrones at our Institute

Microdrones are small-scale unmanned aerial vehicles carrying payloads such as cameras and sensors. Such microdrones enable us to obtain a bird eye’s view of the environment which is helpful in many applications such as in disaster situations. We plan to use these microdrones in a Lakeside Labs research project. In August 2007 we had an impressive demonstration of these devices at our institute.

Institute Retreat

From July 25–27 the Institute of Networked and Embedded Systems had its first retreat. As location hotel Traube in Admont/Styria was chosen. Since the foundation of the institute was only back some months, one of the main topics of this encounter was dedicated to introduce the people and there research topics of the different groups, as well as to present the ongoing research topics and project partners in the different fields.

The second point of the agenda was a workshop on the topic “studying at NES”. Aim of this session was to discuss how to coordinate courses and exams provided at NES, plan advertisement activities for the Information Technology program and to find ways to motivate more students to do their project work at NES.

The morning of the last day was reserved for the Professors of the three groups to present their ideas and experiences about the topics “How to be a good researcher?”, “Steps for a good publication” and “Doing a good Dissertation”. Finally as social event and team building activity a rafting tour at the river Enns finished this first institute retreat.
**Christmas Party 2007**

This year’s Institute’s Christmas party was celebrated at the traditional Felsenkeller, near the brewery Schleppe. The professors thanked all the staff members for their work in the last months und highlighted the well done work. The secretaries were appreciated with flowers. The chair Christian Bettstetter wrote a poetry in the style of “Lasst uns froh und munter sein”. After singing this poetry we were surprisingly not barred of the Felsenkeller. The song wasn't sung so bad (or loud).

**Lasst uns frohe Forscher sein!**


Steht der Notebook auf dem Tisch, hack´ ich manchmal froh und frisch. Lustig, lustig, tralalalala,

bald ist Kaffeepause da, bald ist Kaffeepause da.

Network Coding, Relaying, Smart Kameras und Processing, Lustig, lustig, tralalalala, bald ist ein Ergebnis da, bald ist ein Ergebnis da.

Schick´ ich schnell ein Paper raus, Ein Reviewer schaut gut drauf. Lustig, lustig tralalalala, bald ist auch die Tagung da, bald ist auch die Tagung da.

Fliegen auch die Mikrodrones, mit an Bord die „mobile phones“. Lustig, lustig, tralalalala, ist die Doktorarbeit da, ist die Doktorarbeit da.

Jetzt ist erst mal Ferienzeit, die bringt uns viel Heiterkeit. Lustig, lustig, tralalalala, bald ist Weihnachtsurlaub da, bald ist Weihnachtsurlaub da!

Lyrics by Christian Bettstetter
Based on a co-operation between the Embedded Systems and Signal Processing group and the Belgian research institute IMEC (Inter-university Microelectronics Center) in Leuven, I spent eight months – from January 07 to August 07 – working as a researcher in the Wireless Group of IMEC.

Encouraged by the trend, that more and more ambitious applications are developed for mobile devices, which therefore will create a need for higher transfer rates, we decided to investigate possibilities, which are able to support high data rate transmissions. As such, multi antenna systems promise to handle these requirements by transmitting several data streams simultaneously.

However, due to the increased number of transmissions, interferences between the streams of one user on one hand, and between those of other users on the other hand, are likely to mitigate or even destroy the advantages inherited by multiple antennas. Hence, strategies are required which enable high capacity, while still keeping interferences and therefore bit error rates low. As one possible approach, we chose to investigate precoding techniques. More specifically, using some knowledge about the channel, which is fed back by the receiver, and taking this information to pre-equalize the data streams already at the transmitter, interferences should be attenuated.

Furthermore, in order to make it usable for a practical scenario as well, parameters like the amount and kind of required feedback information have to be taken into account as well. As such, we defined our test system to be a MIMO (Multiple Input Multiple Output) system, where the transmitter has knowledge about the correlation of its antennas.

Using this information, the precoding block aims at minimizing the average minimum mean square error among the different data streams. In terms of error rate, simulation results and analytical verifications showed that an increasing correlation between the antennas only leads to a SNR loss, but it does not change the slope of the bit error rate.

This fact is valid as long as the channel supports the number of independent data streams. (i.e. the rank of the channel matrix is less or equal to the number of independent streams). Furthermore, the diversity order \( D \) is only defined by the number of streams \( N_{\text{str}} \) and receive antennas \( N_r \), but it is independent of the number of transmit antennas \( D = N_r - N_{\text{str}} + 1 \). More in detail, the number of transmit antennas does only influence the coding gain in comparison to the non-precoded case (simple spatial multiplexing).
Frankreich macht Internship in Klagenfurt

Ein Professor an unserer Heimatuniversität hat uns auf die Arbeiten von Herrn Professor Bettstetter aufmerksam gemacht“, erzählen Natacha Castellan und Jean Aviat von der Kontaktherstellung zur Universität Klagenfurt. Die Studierenden der Mathematik und Computerwissenschaften absolvieren ein so genanntes „Internship“ am „Institut für Vernetzte und Eingebettete Systeme“ und sammeln wertvolle Erfahrungen für den späteren Berufseinstieg. „Wir sind herzlich empfangen worden und freuen uns sehr, hier mitarbeiten zu dürfen“, so der einheitliche Tenor.

Wissen durch Praxis


Lakeside Atmosphäre

Das Internship-Programm lässt neben der intensiven Forschungsarbeit aber auch genug Zeit, um viel von der Atmosphäre der Umgebung mitzunehmen. „Der Technologiepark und die Universität sind sehr schön, professionell organisiert und die Menschen mit ihren unterschiedlichen Nationalitäten sind alle sehr freundlich und wirklich offen für Forschungen aller Art“, bestätigen Castellan und Aviat ihre Eindrücke. Neben der Innenstadt von Klagenfurt haben die Studierenden auch bereits Wien und Slowenien besucht. „Es gibt so viel zu sehen und wir werden unseren Freunden empfehlen, unbedingt hier her zu kommen. Klagenfurt ist der richtige Platz für anspruchsvolle Forschung“, ist sich Jean Aviat sicher.

Quelle: Presse&Medien | Universität Klagenfurt
Internship at Siemens Corporate Research in Princeton (NJ, USA)

Thomas Aichholzer was born in 1983 in St. Veit an der Glan (Carinthia), Austria. In June 2002 he attended the technical school (HTL) in Klagenfurt Mössingerstraße for technical informatics and internet engineering. In the summer term 2003 he started to study Informatics at the University of Klagenfurt. From April 2004 to October 2007 he worked as a web developer for the Zentralen Informtikdienst (ZID) at the University of Klagenfurt. In October 2006 he started the bachelor study in information technology at the same university. At the moment he is writing his diploma thesis at Siemens Corporate Research (SCR) in Princeton, NJ (United States).

I’m currently working as intern in the RFID Lab at SRC Princeton where we are developing several solutions in the field of sensor networks. This six month internship is part of my masters thesis on localization topics in sensor networks. My current work deals with the deployment of a service-oriented middleware on an ARM architecture based embedded Linux device called Stargate. The original middleware is supposed to run on i86 and PC architectures, so all architecture dependent parts have to be ported to and cross compiled for the new target architecture. The Stargate computer acts in the sensor network as a Gateway which routes the data from the ZigBee (sensor) network to the usual ethernet network so that PCs or other ethernet devices can connect to this gateway and receive the sensor data which they are interested in.

Working at SCR Princeton is an exciting experience in a multicultural environment. The working atmosphere is very pleasant. For example it is possible to use the gym, to play ping pong or to go outside and play basketball during working hours. At SCR they have no time clock to record your working hours so actually all employees and interns have flexible time.
Technical Infrastructure

The year 2007 brought many changes within the technology infrastructure. These changes have emerged due to the growth of the institute and the new scientific requirements regarding teaching and research. Mainly there are three sections where these changes have taken place, a high tech laboratory, the server infrastructure and working places for students.

Information and communication technology laboratory
The laboratory is mainly intended for the Information Technology students. It consists of eight working places equipped with benches and high performance workstations with high resolution 19” flat screens. The workstations are connected through gigabit-LAN intranet and internet. Further every working place is equipped with adjustable power supplies, soldering stations, signal generators, oscilloscopes, circuit analyser, digital signal processing boards donated by Texas Instruments including the Code Composer Studio and construction sets for a microcontroller board. Additionally the workstations of the laboratory are equipped with licenses for Quartus (Altera), Matlab and Maple.

Server infrastructure
For complex computations and intensive simulations the server infrastructure has been extended to 7 HP ProLiant blades. Each of these blades has two Intel Xeon 3 GHz dual core processors and 10 gigabytes of RAM. To provide sufficient disk space a fibre channel storage area network has been integrated into the infrastructure. This results in a total storage capacity of about 18 terabytes. To provide maximum of scalability the phone infrastructure of the conventional telephone system is currently being replaced by a Voice over IP solution.

Students room
To provide students a possibility to work on their topics a dedicated students room has been established. This room provides about 20 workstations which can be used by students. They are connected to the Internet via a gigabit local area network. In addition to this a wireless access is available all over the two buildings and is being continually expanded.

For the future there are two additional high-tech micro electronic laboratories are planned.
Bewegter Sommer am IT-Campus


Aber nicht nur das: Dieses Team entwickelte auch eine didaktische Bauanleitung, die sie selbst als BetreuerInnen beim Informatik-Kurs des Uni-Talentcamps einsetzten.


Der Sommer endete mit der 1. IT-Campus Party, die am USI-Gelände stattgefunden hat. Ob IT-UnternehmerIn oder IT-ProfessorIn, SchülerIn oder IT-StudentIn, alt oder jung, weiblich oder männlich: alle waren mit Begeisterung und Enthusiasmus beim Wettbewerb um den schnellsten ZORB-Ball dabei.

Quelle: IT-Campus Kärnten

Tag der Forschung 2007

**Forschung aktiv**


Bei den Wirtschaftswissenschaften ließen sich etliche BesucherInnen auf ihre unternehmerischen Fähigkeiten testen und reisten anschließend mit Google Earth um die Welt, um sich bei Veronika Gaube (IFF, Soziale Ökologie) mit www.mein-fussabdruck.at einen persönlichen ökologischen Fußabdruck vermessen zu lassen.

**Info-Blitzlichter**

Wissenswertes, Ergänzendes und auch völlig Neues vermittelten die ForscherInnen mit den Mini-Vorlesungen und den „Blitzlichtern“. Mario Huemer etwa führte vor Augen, wie wichtig das „Alleskönner“-Handy in der heutigen Zeit ist und was wir zukünftig davon erwarten können. Was die Technik von der Natur lernen kann, zeigte Wilfried Elmenreich anhand überraschender Vergleiche von Systemen dem staunenden Saalpublikum.

**Rahmenprogramm**

The Bachelor and Master programs of Information Technology were established in the winter of 2006. To inform the public about the new possibilities in technical studies several PR activities were organized in 2007 in cooperation with IT-Campus Kärnten and the FA PRM (Partner Relation Services) of Klagenfurt University.

21.05.2007
Presentation of Information Technology at the bilingual HAK Klagenfurt (Alexander Onic, Simone Fuchs)

12.07.2007
Presentation of Information Technology to the university internals (Alexander Onic)

14.09.2007
IT-Campus-Party (Alexander Onic)

30.10.2007
Presentation of Information Technology at Kaserne Bleiburg (Alexander Onic)

03.11.2007
Presentation of hardware prototypes for projects in Information Technology at the Atrio, Villach (Thomas Schlechter)

26.11.2007
Presentation of Information Technology at Kaserne Villach (Christian Hofbauer, Michal Gurtowski)

17.12.2007
Presentation of Information Technology at HTL Wolfsberg (Christian Hofbauer, Michal Gurtowski)
Appointments and Responsibilities at the University

Christian Bettstetter

- Head of the Institute of Networked and Embedded Systems
- Professor and Chair of Mobile Systems Group
- Elected member of the Senate
- Chairman of the commission for a full professorship in “Embedded Systems”
- Member of the commission for a full professorship in "Measurement and Control Systems"

Mario Huemer

- Professor and Chair of Embedded Systems and Signal Processing Group
- Vice Chairman of Institute of Networked and Embedded Systems
- Chairman of the commission for a full professorship in “Control and Measurement Systems” at Klagenfurt University
- Member of the curricular-commission for the bachelor and master program “Information Technology”
- Member of the working group „Honorary Professorship for Univ.-Prof. Dr. Michael Fischer“ at Klagenfurt University, May/June 2007

Bernhard Rinner

- Professor and Chair of Pervasive Computing Group
- General Chair and Organizer of ICDSC-07 (First ACM/IEEE International Conference on Distributed Smart Cameras)
- Vice Chairman of Institute of Networked and Embedded Systems
- Member of the curricular-commission for the bachelor and master program “Information Technology”
- Member of the working group „Honorary Professorship for Univ.-Prof. Dr. Hans Albert“ at Klagenfurt University, June 2007
Photos
UNISONO
plus

LAKESIDE LABS
SENIORSTUDIUM LIBERALE

Wir machen es wie die Glühwür...

Die Zukunft

79
The Institute of Networked and Embedded Systems (NES) of the University of Klagenfurt, Austria, works on the design, modeling, and analysis of future networked and embedded systems. We are engaged in research on algorithms and protocols, architectures, networking theory, signal processing, and hardware-oriented issues, with a strong focus on wireless and mobile networks of embedded, pervasive devices and sensors. Current interests include self-organization in networks, networked cameras, cooperative wireless communications, localization and synchronization, and sensor fusion. Our project portfolio includes long-term and short-term research, both in close cooperation with industrial and academic partners. Potential application areas include telecommunications, mobile computing, automotive, and disaster management.

Our teaching activities cover bachelor, master, and PhD courses for the study programs “information technology” and “informatics”. We are committed to giving high-quality lectures, seminars, labs in the areas of signals and systems, circuits and electronics, mobile and wireless systems, pervasive computing, and embedded systems.

Established in the Lakeside Science & Technology Park in January 2007, the institute consists of three research groups: mobile systems (Prof. Bettstetter), embedded systems and signal processing (Prof. Huemer), and pervasive computing (Prof. Rinner). It currently employs 27 people.